DELAWARE SAND FILTER AS AN OPTION FOR STORMWATER RUNOFF

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Abstract. It is well known that stormwater runoff is a major contributing factor to the pollution of the rivers, lakes, and streams across the nation. Currently, some standard sand filters are used as a part of the routine treatment systems for stormwater runoff. Excellent in theory, classical sand filters have caused real problems in practice because they tend to clog very easily. In comparison, the Delaware sand filters might solve many problems attached to common sand filter systems. Additionally, they do not require a pond or pretreatment, and they can be used as separate, totally independent treatment units.

The primary purpose of this project is to monitor, test, and evaluate the effectiveness and efficiency of the Delaware sand filter for long term use in stormwater treatment systems under climatic and soil conditions typical to the South.

INTRODUCTION

In spite of the success of the 1972 Federal Clean Water Act, nonpoint source pollution remains as an urgent problem to be resolved. Stormwater runoff is the one of the biggest carriers of nonpoint source pollutants and a serious cause of water quality problems. Pollutants are picked up by the "first flush" of stormwater, and ultimately, if not treated, they might end in the lakes, streams, and rivers of our nation.

Trying to control this problem, the industries, businesses and municipalities that have major sources of stormwater pollution must apply for discharge permits and use best management practices (BMPs) to reduce the pollution flowing off their property. These BMPs included the use of detention and retention ponds, constructed wetland areas, and filtration systems, as well as, other pollution reducing facilities.

Florida's response to stormwater runoff is addressed in Chapter 62-25 FAC: Regulation of Stormwater Discharge. Chapter 62-25 sets forth design and performance standards, operation and maintenance requirements, and permit requirements for various stormwater facilities such as detention ponds, retention ponds, and constructed wetland areas. It also addresses sand filter systems, but only in a minimal way.

This paper focuses on the potential of sand filter systems and alternative designs, namely the Delaware sand filter.

ULTRA-URBAN STORMWATER MANAGEMENT

Ultra-urban environment is a term used by Bell to characterize highly developed urban areas (W.Bell, L. Stokes, at al 1995). These areas have land that is densely built up with a heavy concentration of structures and paved surfaces, and that has comparatively high land values. The most typical example of an ultra-urban area is the central business district of metropolitan areas. Conventional structural filtration and treatment systems for ultra-urban stormwater management are not practical because of space and cost constraints (Zuber, et al., 1993). Systems such as detention ponds, retention ponds and infiltration trenches are simply too large for high-value urban land. Stormwater runoff in such an environment requires an approach that is less land intensive and works within the constraints of the urban setting. The Delaware sand filter is a system that satisfies the constraints of cost and space.

TYPICAL SAND FILTERS

Sand filter systems are most often used in Florida as a part of a treatment system for stormwater runoff. Usually, they are used in a treatment "train" in which the water flows through several different treatment and storage systems to accomplish the water quality and quantity goals. Sand filters are typically placed at the bottom of detention ponds, and usually consist of a perforated underdrain pipe covered by filter fabric that is then covered by sand. These systems are excellent in theory; however, they have caused real problems in practice, because they tend to clog very easily and very quickly. In a study by the City of Ocala on the Lake Tuscavilla Project, tests on sand filters with different grades of sand concluded that sand of approximately 0.2 mm will clog in less than four hours of filtering, while sand between the sizes of 0.8 to 3.0 mm will clog after forty hours of filtering (Webster, Geoff, 1993). A large amount of maintenance is required to keep these filters functioning properly and prevent them from clogging. Typically maintenance must be performed quarterly and sediment must be removed. The sand and filter fabric must also be routinely replaced, but the lack of easy access to the filter and expensive replacement materials causes extreme problems. Typical removal rates for detention ponds with sand filters as reported by the results of a literature search show that removal rates of total phosphorus, total nitrogen, total suspended solids, BOD, and TKN are in the ranges of 19-80%, 35-80%, 60-100%, 50-100%, 0-80%, and 63-68% respectively (Webster, Geoff, 1993).

DELAWARE SAND FILTER

The Delaware sand filter was originally developed by Mr.Earl Shaver of the Delaware Department of Natural Resources and Environmental Control (Shaver and Baldwin, 1990) as an in-line facility for stormwater collection and treatment. This system stands alone and requires no pond or pretreatment. It consists of two trenches. Water from a parking lot or drainage area flows into the first trench where it is stored. The large suspended solids settle out in the first chamber and as the water reaches a calculated height, it flows through a rectangular weir into the second trench. This trench consists of the sand filter, typically with 18 inches of sand in place with no underdrain pipe. Instead, the water flows through the sand to a mesh filter grate at the bottom of the filter. The water then leaves the system though an outfall pipe near the mesh filter grate. The first trench is usually covered by grated steel through which the water flows. The second trench (the filter) is usually covered by steel plates. The grated steel and steel plate covers are easily removable allowing for very easy maintenance. Also, since most of the large particulates settle out in the first trench, the sand filter does not clog as quickly requiring less maintenance and replacement.

Figure 1 shows the general design of a typical Delaware sand filter. This system takes up less space than typical detention ponds. It can be placed in shallow areas with high groundwater tables, and the whole system is underground offering convenience and aesthetic value. Typical removal rates for Delaware sand filter systems as reported from a

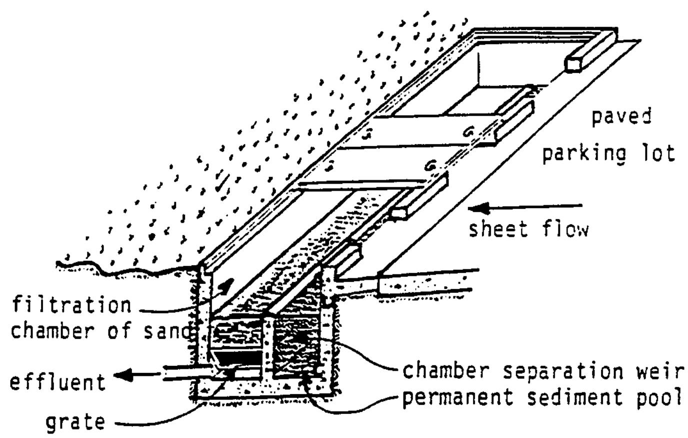

Figure 1. Design of Delaware sand filter.
(Based on drawings provided: Bell, at al, 1995)

study done by Warren Bell of the City of Alexandria Virginia, Department of Transportation and Environmental Services shows that removal rates of total phosphorus, total nitrogen, total suspended solids, BOD, and TKN are 72.3%, 47.2%, >80%, 77.5%, and 70.6% respectively (W. Bell, L. Stokes, *et al*, 1995).. These removal rates are consistent and sometimes better than the removal rates for detention ponds with sand filters.

Among the advantages of the Delaware sand filter, the system offers ease of accessibility, less maintenance, and less use of less space while still removing pollutants and storing stormwater runoff. Such factors are of critical importance in urban areas, where urban stormwater runoff is the biggest water quality problem. If the Delaware sand filter can be shown to meet water quality requirements, it can make a substantial contribution to solving urban stormwater runoff problems.

CONSTRUCTION AND MONITORING

The primary purpose of this project is to monitor, test, and evaluate the effectiveness and efficiency of Delaware sand filters for long term use in stormwater treatment systems under climatic and soil conditions typical to Florida, using Tallahassee as the locus of the study.

After investigation of several potential sites, we selected the parking lot in front of the FAMU-FSU College of Engineering building as the most suitable for construction and long term monitoring, and probably at the lowest cost to the project. The paved parking lot is more than an acre, has almost 150 parking spaces and drains directly to a detention basin as depicted in Figure 2. By intercepting the

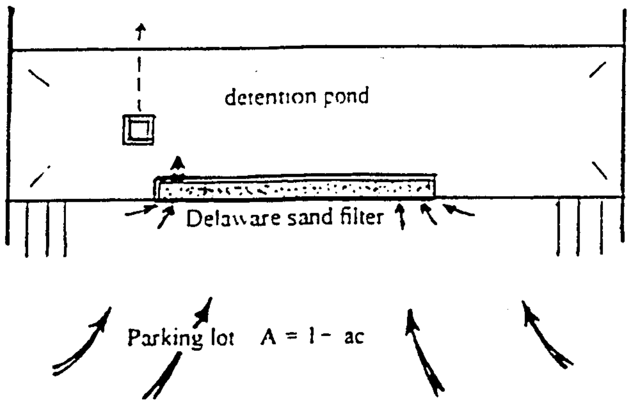

Figure 2. General project layout

runoff before it enters the detention basin, the site readily lends itself to construction of a Delaware sand filter with direct runoff from the parking lot and without any pretreatment or filtering. The final design and construction of the sand filter for a parking lot of this size will be about 2 m wide x 1 m deep x 30 m long. After the filter is built, we turn to the major focus of this study, namely monitoring and evaluating the filter. We anticipate that we will take regular weekly samples from summer 1997 to summer 1998, plus occasional storm event samples. The sampling will be done at both influent to and effluent from the filter. Among the parameters we expect to measure is pH,total suspended solids (TSS), total dissolved solids (TDS), chemical oxygen demand (COD), conductivity, total organic carbons (TOC), volatile organic carbons (VOC), and trace elements. Analysis of the soil samples for the presence of hydrocarbons will be performed, too.

CONCLUSIONS

In order to adequately address the major unresolved water quality problem in the United States, concerted efforts for improving stormwater runoff quality will have to be made under the National Pollution Discharge Elimination System (NPDES). In addition to Best Management Practices directed at reducing pollutants that become part of stormwater runoff, a number of innovative methods are being used. Among them are natural wetlands, constructed wetlands, detention and retention ponds, and various types of filters, the Delaware sand filter offers particular promise for improving water quality in highly urbanized areas through the use of a relatively compact filter design that is readily maintained and that gives significant reduction in various types of pollutants associated with runoff from heavily traveled pavements.

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